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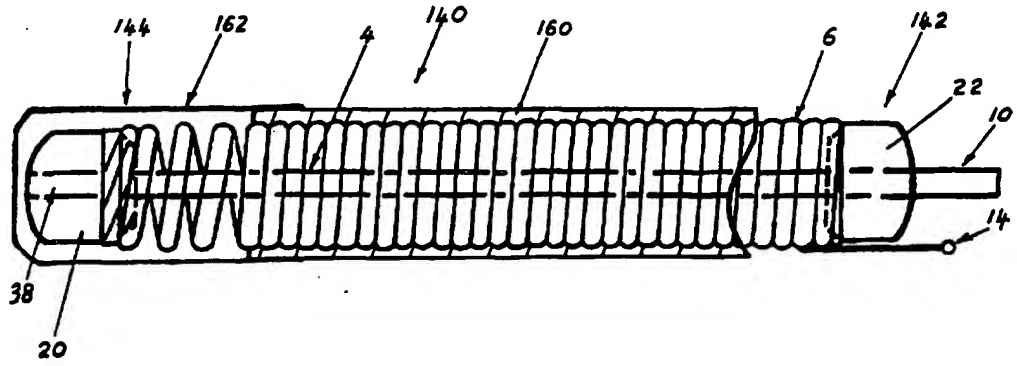

(57) Abstract

A flexible variable resistor (2, 50, 60, 140) comprising an outer flexible element (6), an inner flexible element (4), means (18, 20, 22) for mounting the inner flexible element in tension within the outer flexible element, the arrangement being such that, when said elements are deflected, points of contact (34, 36) therebetween will vary as deflection varies characterised in that at least one of the outer and inner flexible element includes resistive material whereby the electrical resistance between said elements varies with deflection thereof.

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VARIABLE RESISTOR, INDUCTOR OR CAPACITOR

This invention relates to electrical components.

More particularly, the invention relates to electrical components which have variable characteristics.

Australian Patent No. 652,385 discloses a flexible switch construction. The invention herein concerns improvements in the switch construction described in that specification in order to permit construction of a variable resistance element, a variable capacitance element or a variable inductance element. The principles of the invention also permit construction of miniaturised variable components.

According to the present invention there is provided a flexible variable resistor comprising an outer flexible element, an inner flexible element, means for mounting the inner flexible element in tension within the outer flexible element, the arrangement being such that, when said elements are deflected, points of contact therebetween will vary as deflection varies characterised in that at least one of the outer and inner flexible element includes resistive material whereby the electrical resistance between said elements varies with deflection thereof.

The invention also provides a data glove which includes sensing elements mounted in one or more fingers of the glove in order to provide positional data characterised in that the sensing elements comprise flexible variable components described above.

The invention will now be further described with reference to the accompanying drawings, in which:

Figure 1 is a schematic view of a variable resistor constructed in accordance with the invention;

Figure 2 shows the variable resistor bent about a body;

Figure 3 shows the variable resistor having one end fixed and bent into U-

shapes;

Figure 4 is a more detailed side view of a variable resistor of the invention;

Figure 5 shows in more detail forming a centre connection of a variable resistor of the invention;

Figure 6 schematically illustrates the way in which the variable resistor functions;

Figure 7 is a fragmentary sectional view through a variable resistor of the invention;

Figure 8 is a schematic circuit representation of a variable resistor of the invention;

Figure 9 is a schematic circuit representation of a modified form of resistor of the invention;

Figure 10 is a schematic circuit representation of a modified variable resistor of the invention;

Figure 11 shows a half-bridge circuit incorporating a variable resistor of the invention;

Figure 12 shows the use of a flexible variable resistor in a data glove;

Figure 13 shows the manner in which the variable resistor functions in the data glove;

Figure 14 is a fragmentary cross-section through a variable inductance constructed in accordance with the invention;

Figure 15 is a fragmentary cross-sectional view through a variable capacitance constructed in accordance with the invention;

Figure 16 shows a variable frequency oscillator utilising a variable inductance of the invention;

Figure 17 shows a variable frequency oscillator utilising a variable capacitance of the invention;

Figure 18 is a block diagram showing a variable pulse circuit or variable voltage circuit constructed in accordance with the invention;

Figure 19 is a circuit realisation for the arrangement shown in Figure 18;

Figure 20 is a side view of a modified form of variable resistor of the invention;

Figure 21 is a fragmentary view of the arrangement shown in Figure 20;

Figure 22 is a schematic circuit realisation of the device shown in Figures 20 and

21; and

Figure 23 shows a variable resistance device having a protective sheath thereon.

Figure 1 diagrammatically illustrates a variable electrical component 2 of the invention. It comprises a flexible inner element 4 and a flexible outer element 6. Terminals 8 and 10 are provided at the respective ends of the inner element 4. Terminals 12 and 14 are provided at the respective ends of the outer element 6 for making electrical contact therewith.

Figure 4 shows more detail of this configuration. It will be seen that the outer component 6 takes the form of a spring, a first portion 16 of which is in the form of a tension spring and the second portion 18 of which is in the form of a compression spring. The inner element 4 is mechanically coupled to one end of the tension portion 16 by means of an insulating clamping member 20. The other end of the inner element 4 is connected to the free end of the compression spring portion 18 by means of an insulating clamping component 22. As in the switch configuration shown in Australian Patent No. 652,385, the central element 4 is held in tension because of the compression spring portion 18 of the outer component. The active part of the component can be regarded as that which is co-terminus with the length of the tension spring portion 16. When the variable component of the invention is bent, its electrical properties alter as will be described below. Figure 1 diagrammatically illustrates an arrangement in which the component is bent about its centre. Figure 2 shows an arrangement in which the component 2 is bent about a cylindrical object 24. Figure 3 shows an alternative arrangement in which one of the ends of the component 2 is fixed and the component is bent so as to have a generally U-shaped portion 26. All of these variations (and others) will result in varying the resistance of the component.

In the rest condition of the component 2 of the invention, that is to say when it is straight, there is a gap 26 between the core element 4 and outer element 6. When, however, the component 2 is subjected to bending as diagrammatically illustrated in Figures 1, 2 or 3, the outer element 6 will bend with a different radius of curvature to the core element 4 and these elements will contact one another, as diagrammatically

illustrated in Figure 6. In this arrangement, there is a central region 28 where there is generally continuous contact between the elements 4 and 6. At the ends of the component there are end portions 30 and 32 where there is no contact between the elements 4 and 6. The portions 30 and 32 effectively define two separate variable resistance components. For the portion 30, the terminals 8 and 12 can be used to sense the resistance of that part of the element 4 between the terminal 8 and the point 34 of contact with the outer element 6. Similarly, for the component portion 32, the terminals 10 and 14 can be used to determine the resistance of the element 4 from the terminal 10 to the point of contact 36 of the element 4 with the outer element 6.

It will be appreciated that as the bending of the component 2 changes, the points of contact 34 and 36 vary and accordingly the resistance sensed between the terminals 8 and 12 and the terminals 10 and 14 varies. As will be appreciated by those skilled in the art, these variable resistances can be applied in a multiplicity of different circuit arrangements. In the arrangement of Figures 1 to 4, the element 4 is insulated from the element 6 when straight. Thus it is effectively an open circuit element like an open switch. When bending first takes place electrical contact is made and it can be regarded as switching into circuit a resistance. As bending increases, the effective value of the resistance decreases. The component 2 thus can be considered to exhibit combined switching and variable resistance characteristics.

Figure 7 illustrates in more detail a preferred embodiment of the variable resistor of the invention. The inner element 4 comprises a core 38 such as a seven strand 304 stainless steel cable 0.35mm outer diameter with a nylon outer sheath 40 which is 0.15mm in thickness. The cable and sheath being 0.55mm in diameter. A resistive coil 42 is wire wound or wire wrapped over the nylon sheath 40 which acts as a former to maintain each turn of the coil 42 separate from adjacent turns. The outer flexible element 6 is preferably formed from 304 stainless steel wire 0.38mm in diameter. The element 6 preferably has a 2.58mm outer diameter, 2.2mm inner diameter and is 48mm in length. In the illustrated arrangement, the outer surface of the sheath 40 is provided with a helical groove 44 which acts as a former for the turns of the coil 42.

In the preferred form of the invention, the groove 44 can be formed during the winding process of the coil 42. In this arrangement, the sheath 40 is initially smooth on its outer surface and together with the core 38 is held in tension between two rotating centres (somewhat similar to a lathe). The resistive wire which forms the coil 42 is then wound at a control feed rate along the rotating sheathed cable. A small electric current is applied to the resistive wire by means of contact wipers that contact the last few turns which have been applied to the sheath 40. Another contact engages the resistive wire that is about to be applied to the sheath 40. The contacts are mounted on a travelling carriage which determines the longitudinal feed rate of the winding of the wire on the sheath. The electric current which flows in the wire causes momentary heating of the wire 42 and the amount of current is adjusted so that the heat is sufficient to locally melt the outer surface of the sheath 40 so as to form the helical groove 44. In this way, the coil 42 is very securely affixed to the sheath 40 and is normally insulated from the stainless steel core 38. The resistance of this device typically varies between 100 and 300 ohms generally proportionately to the amount of bending of the component.

Figure 5 schematically illustrates a modified form of the variable resistor 50 constructed in accordance with the invention. In this arrangement, the metallic core 38 forms part of the electrical connection to the coil 42. An uninsulated gap 52 is provided in the sheath 40 so that a number of turns 54 can be wound directly on the cable 38. A good electrical connection can be established by means of a solder joint 56. In this arrangement, the nickel chrome resistive wire which makes up the coil 42 can be continuous even though there are separate segments of the coil 42 on either side of the uninsulated gap 52. In one arrangement, the uninsulated gap 52 may be provided at the centre of the device 50. In this case, it may be desirable to arrange for the direction of winding of the coil on either side to be in opposite senses so as to eliminate inductance. In other arrangements, the uninsulated gap may be provided at either end of the device.

The arrangement shown in Figure 5 has the advantage that a robust electrical connection can be made through the cable 38, that is to say the terminals 8 and 10 can be connected to the ends of the cable 38. This avoids the need for the relatively fine resistance wire forming the coil 42 to form part of the terminations. The ends of the

coil 42 can simply be glued or heat shrink sleaved to the sleave 40 in order to fix their positions. Figure 9 is a diagrammatic circuit representation of a centre terminated resistive component 50. It will be seen in this representation that the cable 38 is coupled to the terminals 8 and 10.

In a further modified form of the invention, a plurality of separately insulated cables 38 can be provided and a number of different resistance coils 42 can be wound about the group of cables 38. Each of the individual coils can be soldered to the respective cables. In this way, a composite device can be made which has a plurality of variable resistors therein which can be separately sensed. Figure 10 is a diagrammatic circuit representation of a centre terminated resistive component 60 which has dual axially extending cables 38 and 39 soldered to respective coil segments 42 and 43 by solder joints 56 and 57.

The variable component 60 thus provides dual potentiometers, each of which has terminals 8 and 12 and 10 and 14 which, at the ends of the component 60, do not contact the coils 42 and 43.

Figure 11 diagrammatically illustrates a sensing circuit 62 incorporating a variable resistance device 2 of the invention. It will be seen that the device 2 is connected in series with a known resistor 64 to form a simple resistive bridge. An input voltage V_{in} is applied between input terminals 66 and 68. An output voltage V_{out} is sensed at the node 70 between the resistors 2 and 64. As the component 2 of the invention is progressively flexed or bent, its resistance will gradually increase and so the output voltage V_{out} will increase by a proportionate amount. It will be appreciated by those skilled in the art that the sensing circuit 62 of the invention can be used in a multiplicity of applications where it is necessary to sense deflection, displacement or forces applied to a component.

It will be appreciated that a second bridge circuit can be provided for monitoring the change in resistance between the terminals 10 and 14 of the component 2 if required.

It will be appreciated of course that the variable resistance components 50 and 60 shown in Figures 9 and 10 can readily be incorporated into a sensing circuit similar to that shown in Figure 11.

Figures 12 and 13 diagrammatically illustrate the use of a variable resistance component 50 in a data glove which can be used for providing positional information, such as the fingers on a hand for input to a virtual reality system. In this arrangement, the data glove 72 is provided with a number of fingers 74, each of which has fastened thereto a variable resistance component 2 of the invention. As can be appreciated from Figure 12, the degree of flexure of the finger will alter the resistance of the component of the invention and this can be sensed using a sensing circuit 62 similar to that shown in Figure 11.

Figure 13 illustrates schematically an improved arrangement where a variable resistance component 60 having two separately accessible sections is provided. Each of these is associated with the distal and inner parts of the finger as shown by the broken lines thereby providing more information about the relative positions of the various parts of the finger.

It will be appreciated of course that the variable resistance devices of the invention can be used to provide positional data for other parts of a human body. Of course the same techniques can be used to provide positional data for any form of animated object having relatively movable parts.

It will be further appreciated that the inner element 4 of the invention can be constructed in a number of different ways. For instance, it may in some circumstances be desirable to form a flexible conductive body which comprises a resilient plastics material such as PTFE, polypropylene or the like in which is dispersed minute particles of conductive material. Material of this sort behaves as a resistive component which is inherently flexible.

The invention also provides variable inductances and capacitances and sensing

circuits incorporating these components.

Figure 14 diagrammatically illustrates a section through a preferred form of inductance 80 constructed in accordance with the invention. This structure is somewhat similar to that shown in Figures 4 and 7 and the same reference numerals are used to denote corresponding parts. In this arrangement, the inner element 4 comprises a flexible insulating body 82 which may comprise for instance a strand of nylon or the like. The coil 42 is wound about the core 82 and in this case, it is appropriate to use an insulated wire 84 to form the coil 42. It is preferred not to use resistive wire for forming the coil 42. The use of an insulated wire 84 is possible because the functioning of the variable inductors does not rely on electrical contact between the coil 42 and the outer element 6 as in the case of the resistance 2. The variable inductance 80 provides a variation in inductance due to the change in the relative proximity of the individual turns of the coil 42. The change in inductance can be sensed between the terminals 8 and 10 connected to respective ends of the coil 42. In this case, the outer flexible spring 6 acts to physically support or hold the centre flexible inductive component 4 in tension and is not necessarily electrically active.

The invention also provides a variable capacitance 90 as diagrammatically shown in Figure 15. This arrangement is somewhat similar to that illustrated in Figures 4 and 7 and accordingly the same reference numerals have been used to denote parts which correspond to one another. In this arrangement, the coil 42 is eliminated and the insulating sheath 40 is made from a dielectric material such as nylon. In this example, the flexible cable 38 comprises a seven strand stainless steel cable having a nylon outer sheath 40 as a dielectric insulator. The diameter of the cable and coating is preferably about .5mm in diameter. The outer component 6 comprises a tension-compression spring which is preferably 2.5mm outside diameter and may have a length of say 48mm. A device of this example has a capacitance of the order of 10 picofarads when straight and when deflected the capacitance increases to the order of about 18 picofarads on full deflection. The capacitance can be increased by selecting materials for the sheath 40 which have a higher dielectric value.

The variable capacitance arrangement 90 can operate as a variable capacitance device similar to that shown in Figure 6. Varying capacitance can be sensed between terminals 8 and 12 connected to the cable 38 and outer element 6 respectively. At the other end of the device 90, the variable capacitance can be sensed between the terminal 10 which is connected to the cable 38 and to terminal 14 which is connected to the outer spring 6.

It will be appreciated by those skilled in the art that the variable inductance 80 and variable capacitance 90 can be coupled in various sensing circuits in order to provide electric signals which are responsive to deflection of the components 80 and 90.

Figure 16 diagrammatically shows an example of sensing using a variable inductance 80 of the invention. In this arrangement, a variable frequency oscillator 100 is provided. It comprises a well known Colpitts circuit in which a variable inductance 80 forms part of a bridge circuit coupled to the gate of a transistor 102. A variable frequency output appears on output terminal 104, the frequency being dependent upon the degree of bending or flexure of the variable inductance 80 of the invention.

It will be appreciated that a variable capacitance 90 of the invention can be utilised in the oscillator 100 to produce a variable frequency output. In this arrangement, it would be possible to use a variable capacitor 90 in place of the inductance 80 and replace the capacitor 106 with a fixed inductor, the terminal 14 being earthed.

Figure 17 shows a variable frequency oscillator 120 constructed in accordance with the invention. This oscillator utilises a variable capacitor 90 coupled as part of an RC feedback network to a Schmidt trigger inverter amplifier 122. In this arrangement, as the variable capacitance component 90 of the invention is bent or deflected, its capacitance will increase, thereby altering the output frequency appearing on output terminals 124 and 126.

Figure 18 shows a detection circuit 130 which utilises a variable capacitance 90

of the invention in order to produce a variable pulse width on output line 132 or a variable voltage level on output line 134. The circuit includes a square wave oscillator 136, the output of which is connected to a bridge circuit which includes two RC arms, one of which includes the variable capacitor 90 of the invention. A level detect circuit 137 is coupled to monitor the voltage on the capacitor 90 and its output is coupled to the RESET input of a flip flop 138. Another level detecting circuit 140 monitors the voltage level on a reference capacitor 142 and its output is coupled to the SET input of the flip flop 138. The output of the flip flop 138 provides a variable pulse width on line 132 which varies in accordance with the degree of bending or flexure of the variable capacitance 90. The flip flop output is filtered by means of an RC network 144 in order to provide a voltage on output line 134 which varies in accordance with the degree to which the capacitor 90 bends or deflects.

Figure 19 shows a circuit realisation for the detecting circuit 130. The manner in which this circuit functions would be understood by persons skilled in the art and therefor need not be described in detail.

The variable resistors which are described above in relation to Figures 1 to 9 can be considered as circuit elements which include a switching function as well as providing variable resistance. This is because when the components are not flexed, the resistive coil does not make electrical contact with any other components. Thus the device is essentially functionally equivalent to an open switch. When, however, deflection occurs, electrical contact is made between the wound coil 42 and the tubular conductor 6. This initial contact can, in some circumstances, be utilised as a switching function. As deflection continues, normally resistance will decrease at a rate which is proportional to the deflection of the component.

Figures 20 to 22 diagrammatically illustrate an alternative embodiment of the invention which eliminates the switching function, that is to say the variable resistance device 140 of this embodiment does not have a switching function and will always exhibit some degree of resistance. In these drawings, the same reference numerals have been used to denote parts which correspond to those of previous embodiments, where

appropriate.

In this embodiment, the variable resistance component 140 includes a mounting end 142. In this configuration, the terminal 10 is in the form of a tubular conductive pin which receives and is electrically connected to the end of the cable 38, as diagrammatically illustrated in Figure 21. The resistive coil 42 is wound on an insulating sheath 40 as in the case of Figure 7. At the free end 144 of the component, a conductive end disc 146 is mounted on the sheath 40. The end of the coil is soldered or electrically connected to the disc 146 by means of a solder joint 148. The disc 146 includes a peripheral rebate 150 which receives and centres the end of the outer tubular coil 6. The clamping body 20 is fixed to the end of the cable 38 so that the compression spring portion 18 of the outer element 6 keeps the cable 38 in tension.

When the component 140 is undeflected, the full length of the resistive coil is electrically connected between the terminals 10 and 14. When, however, a deflective force is applied to the free end 144 of the component 140, it will deflect and a point of contact 152 between the coil 42 and the outer element 6 will be established, as diagrammatically illustrated in Figure 6. As deflection continues, the point of contact 152 will move closer to the mounting end 142 of the component whereby its effective resistance value progressively decreases.

Figure 23 diagrammatically illustrates the use of a protective outer sheath 160 which preferably comprises an elastomer coating applied to the outer surface of the element 6. The sheath 160 may cover the entire element so as to protect it from dirt, moisture and the like. In the illustrated arrangement, a rigid end cap 162 is provided so as to provide extra protection for the free end of the device which may come into contact with other components. Also, the cap 162 provides additional clearance for the compression spring portion 18 so as not to interfere with its ability to apply tensile forces to the inner element 4.

Many modifications will be apparent to those skilled in the art without departing from the spirit and scope of the invention.

CLAIMS:

1. A flexible variable resistor comprising an outer flexible element, an inner flexible element, means for mounting the inner flexible element in tension within the outer flexible element, the arrangement being such that, when said elements are deflected, points of contact therebetween will vary as deflection varies characterised in that at least one of the outer and inner flexible element includes resistive material whereby the electrical resistance between said elements varies with deflection thereof.

2. A resistor as claimed in claim 1 wherein the inner flexible element includes a wound coil of resistance wire which contacts the inner surface of the outer flexible element on deflection of said elements.

3. A resistor as claimed in claim 2 wherein said coil is wound on an insulating body.

4. A resistor as claimed in claim 3 wherein said body comprises a sleeve of insulating material through which a strand of wire passes.

5. A resistor as claimed in claim 4 wherein said means for mounting the flexible element includes clamping bodies which serve to clamp the ends of said strand of wire to the ends of the outer flexible component and wherein the outer flexible component includes a compression spring which thereby operates to maintain said strand under tension.

6. A circuit for detecting deflection of a flexible device comprising a bridge circuit wherein at least one arm of the bridge circuit includes said flexible device and wherein said device comprises a variable resistor as claimed in claim 1.

7. A data input device for inputting positional data relating to an object to virtual reality apparatus, said device including a variable resistor as claimed in claim 1 and coupling means for coupling said variable resistor to said object.

8. A data input device as claimed in claim 7 wherein said object is a hand or other body part and said coupling means comprises a glove or other clothing adapted to be worn by a user of the virtual reality apparatus.

9. A method of winding a coil comprising the steps of winding a coil of resistance wire on an insulating former, heating the wire during winding thereof so as to partially melt the former so as to form a helical groove in said former which serves to maintain separation of adjacent turns in said coil.

10. A method as claimed in claim 9 including the steps of maintaining said coil in a state of tension within a flexible conductive outer component, the arrangement being such that on flexure of the outer component and coil, points of contact therebetween will vary.

11. A flexible variable inductance comprising an outer flexible element, an inner flexible element, means for mounting the inner flexible element in tension within the outer flexible element, and terminal means for establishing electrical contact at respective ends of said inner flexible element, said inner flexible element including an elongate helically wound coil comprising a multiplicity of adjacent turns, the arrangement being such that when the outer and inner elements are caused to deflect the relative positions of said adjacent coils vary as a function of the degree of deflection whereby the inductance sensed between said terminal means varies with deflection of said elements.

12. An inductance as claimed in claim 11 wherein said coil is wound from insulated wire.

13. A variable frequency circuit including at least one LC network wherein the inductance therein comprises a variable inductance as claimed in claim 11.

14. A flexible variable capacitance comprising an outer flexible element, an inner flexible element, means for mounting the inner flexible element in tension within the

outer flexible element, wherein the outer and inner elements are conductive and a dielectric insulator is located between said outer and inner elements, the arrangement being such that when said elements are deflected the relative positions of said elements varies as deflection varies whereby the capacitance between said elements varies with deflection of the elements.

15. A capacitance as claimed in claim 14 wherein said dielectric insulator comprises a sheath of flexible dielectric material surrounding said inner conductive element.

16. A capacitance as claimed in claim 15 including an annular air gap between the inner surface of the outer element and said sheath.

17. A variable frequency circuit including at least one RC network wherein the capacitance therein comprises a variable capacitance as claimed in claim 14.

18. A circuit as claimed in claim 17 wherein said RC network is coupled as a feedback circuit of a Schmidt trigger inverter amplifier.

19. A resistor as claimed in claim 1 including a said inner element is electrically insulated from said outer component except when contact occurs as a result of differential bending thereof.

20. A resistor as claimed in claim 1 wherein one end of said inner element is electrically connected to said outer component.

21. A resistor as claimed in claim 20 wherein including a mounting end including first and second terminals the terminals first terminal being electrically connected to said outer element and the second terminal being electrically connected to the inner element remote from the mounting end.

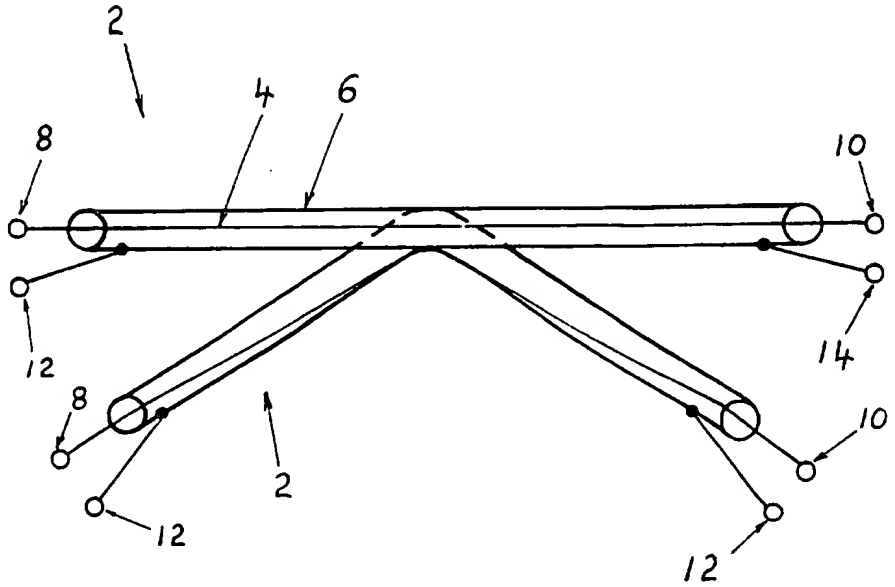


FIG 1

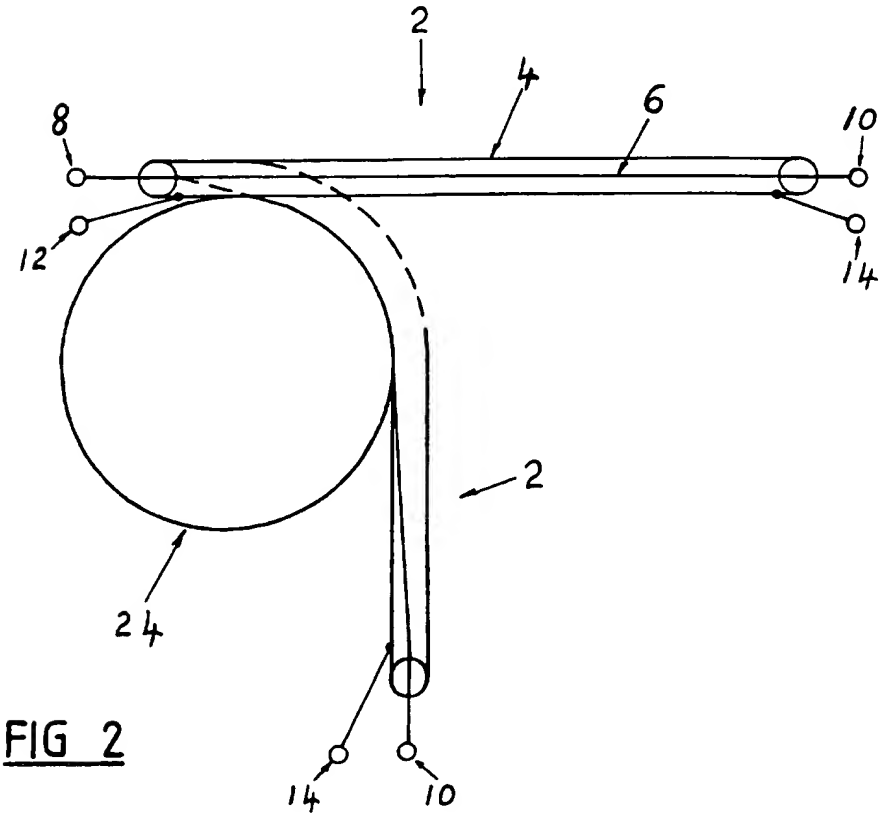


FIG 2

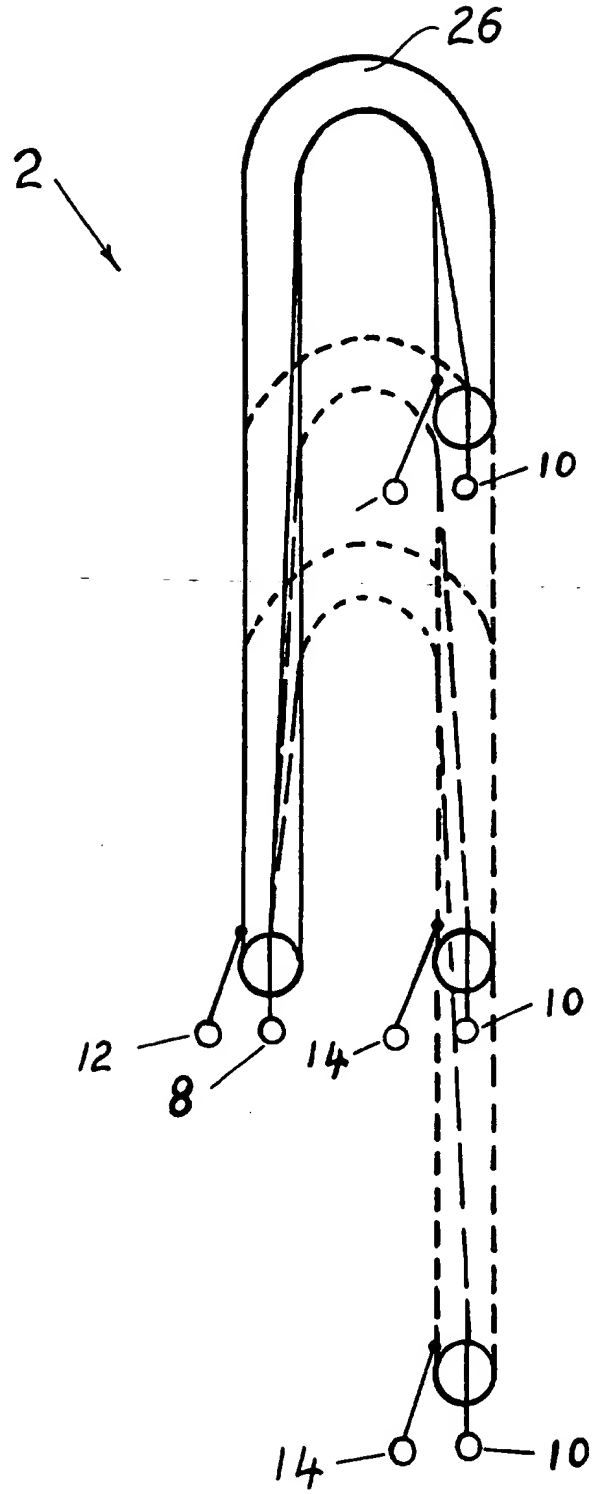


FIG 3

FIG 4

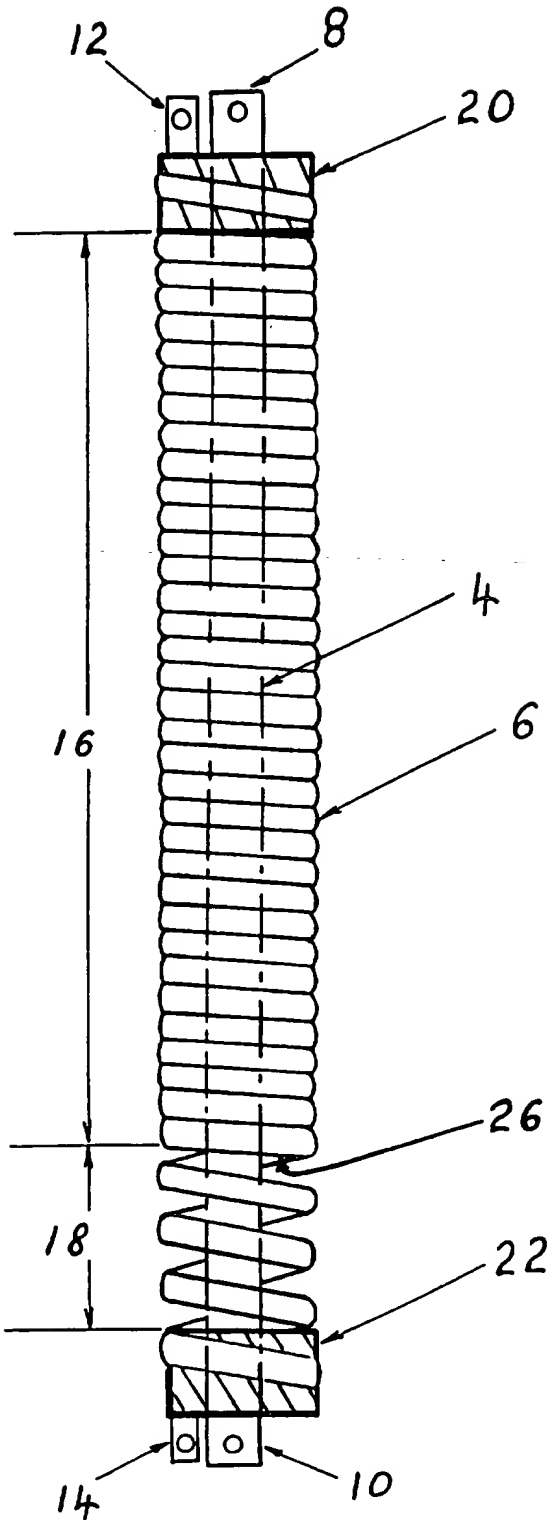
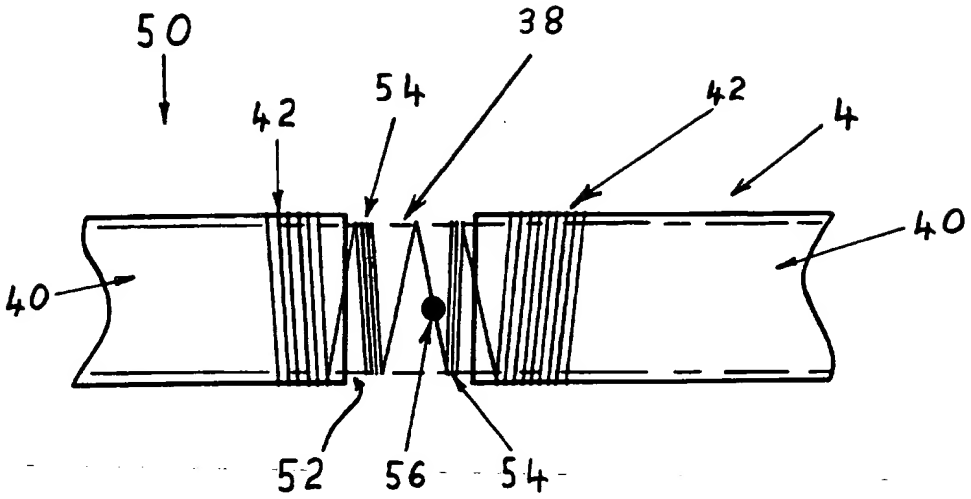


FIG 5



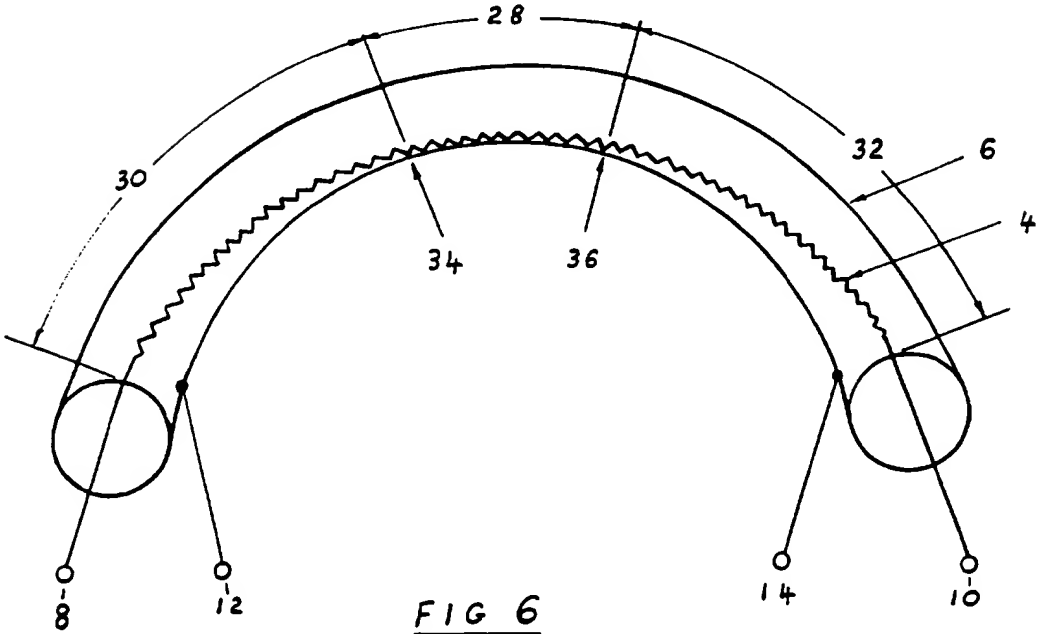


FIG 6

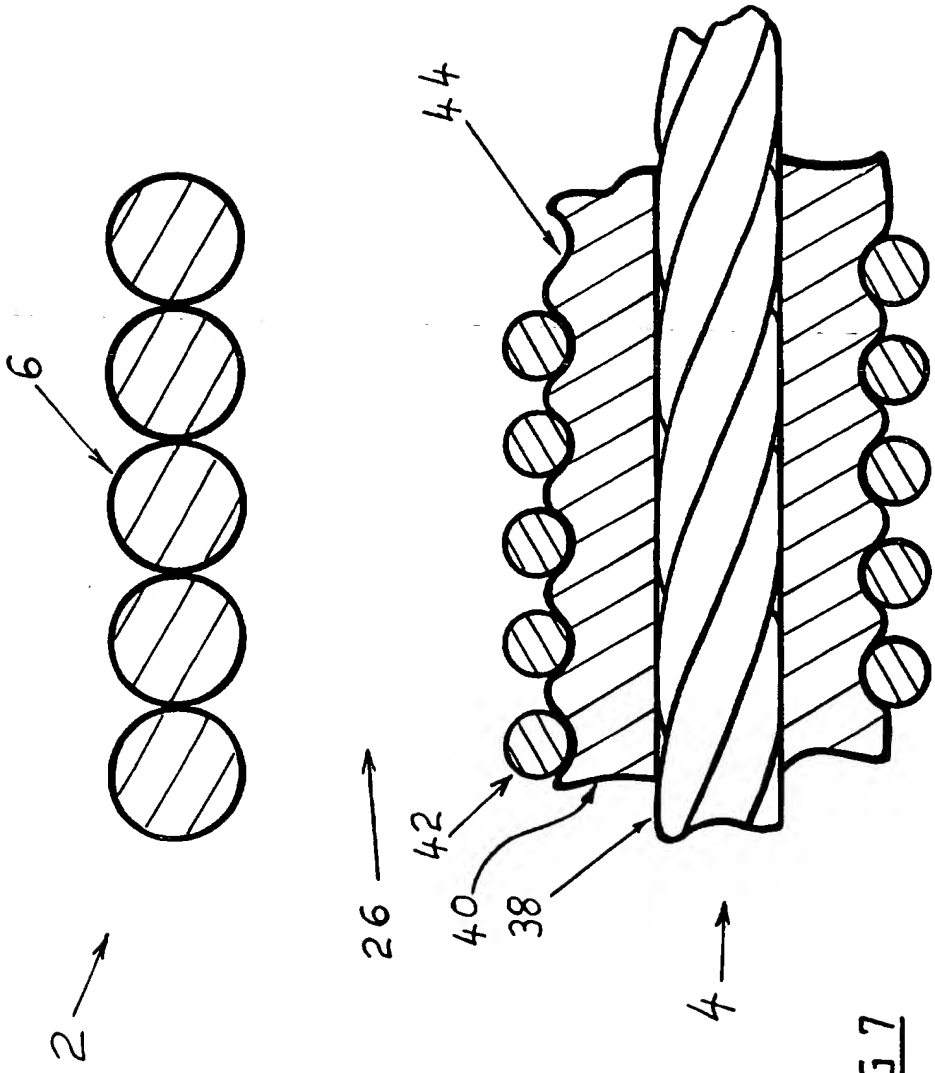


FIG 7

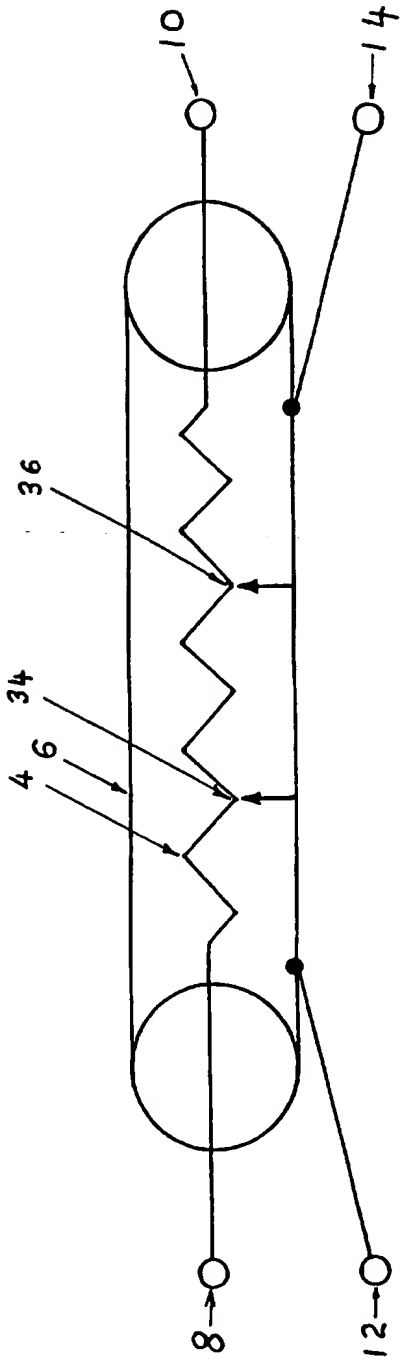


FIG 8

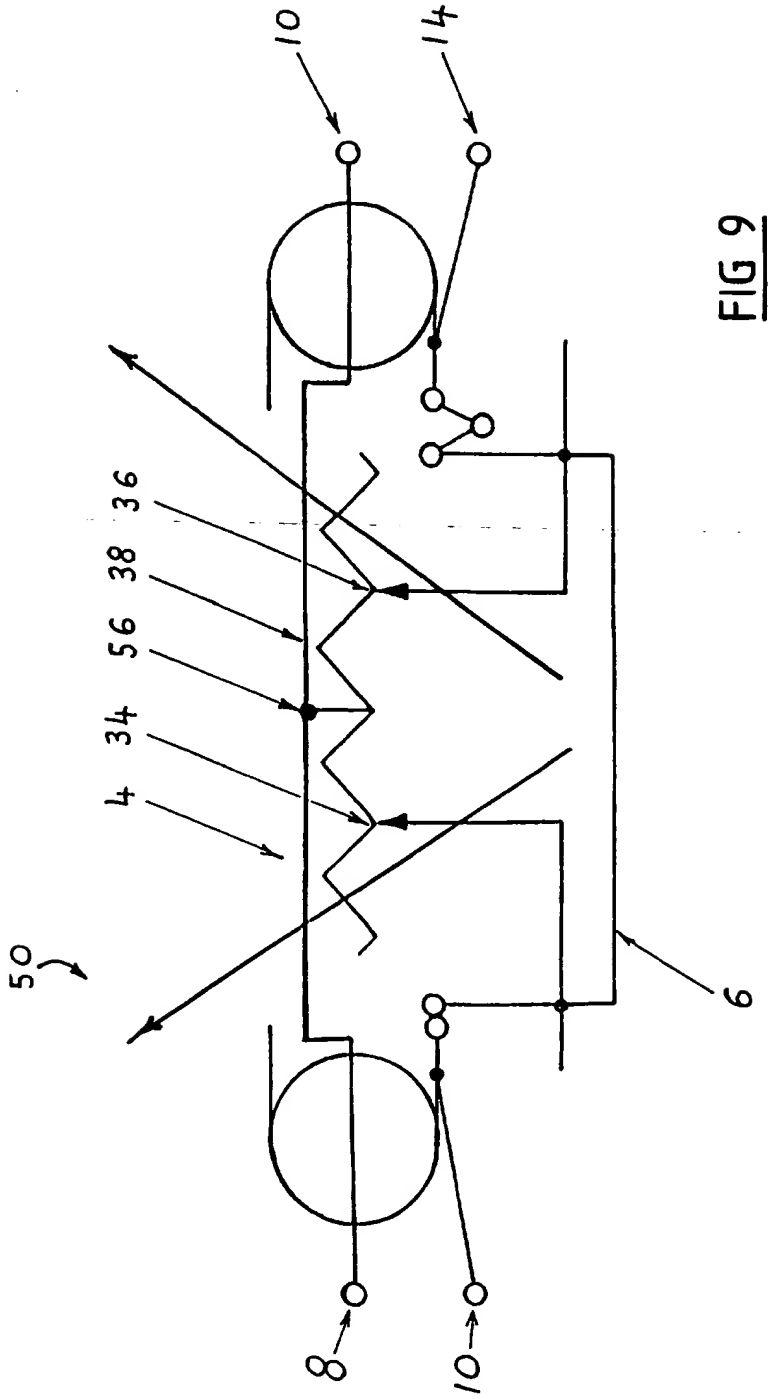


FIG 9

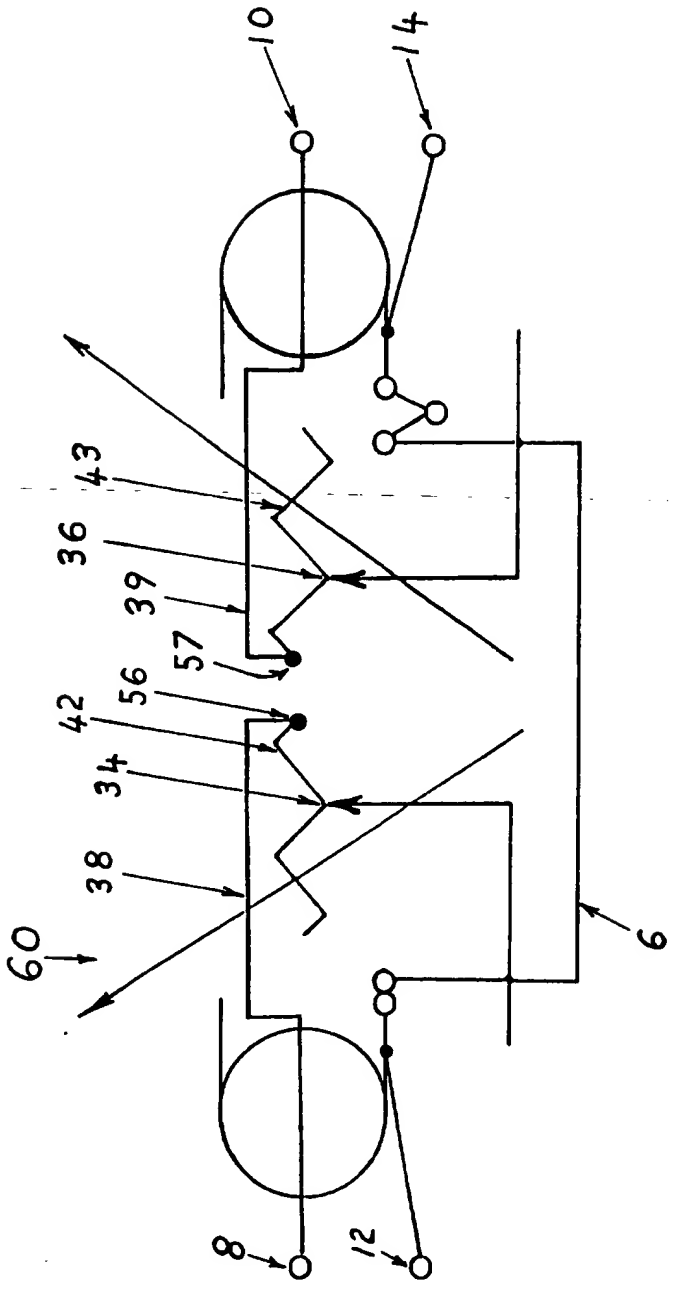


FIG 10

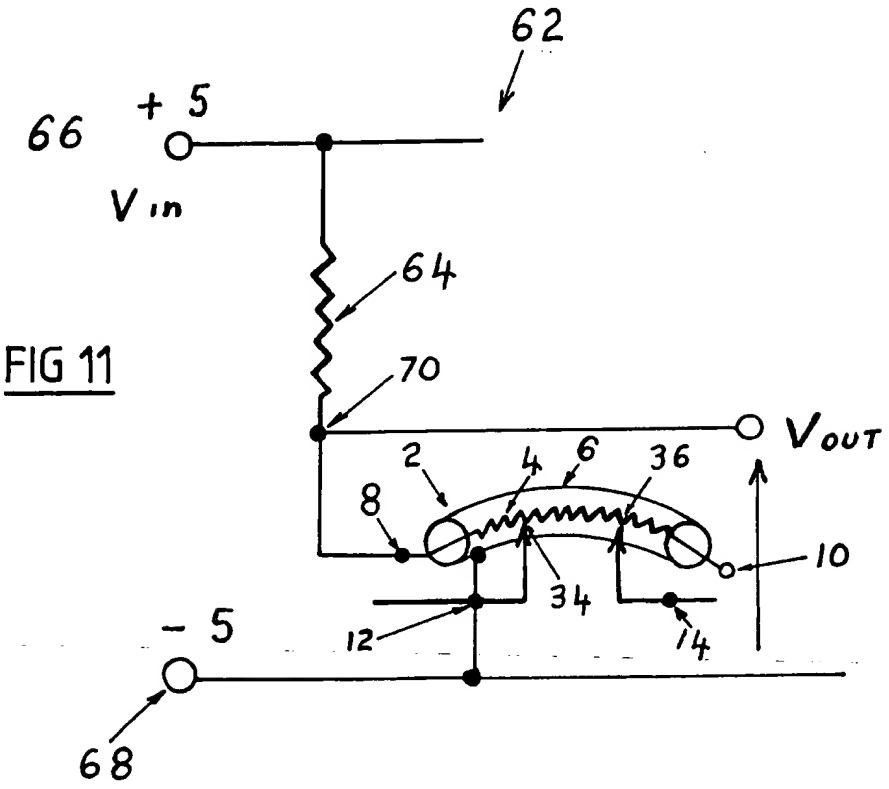


FIG 11

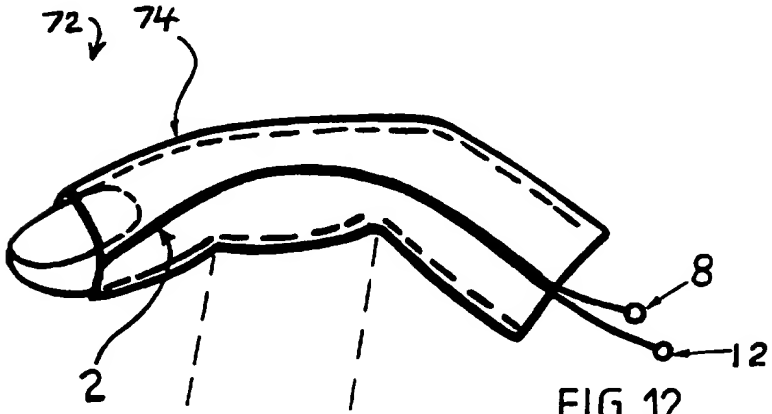


FIG 12

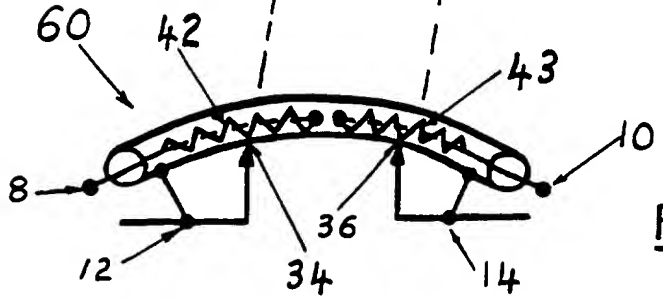


FIG 13

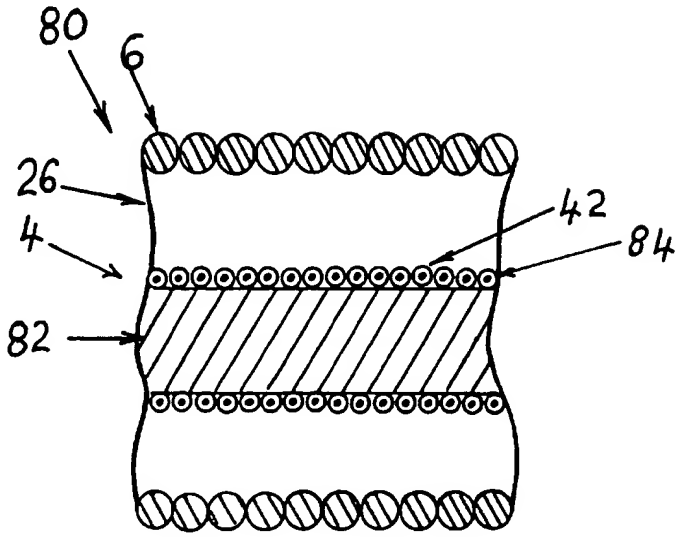


FIG 14

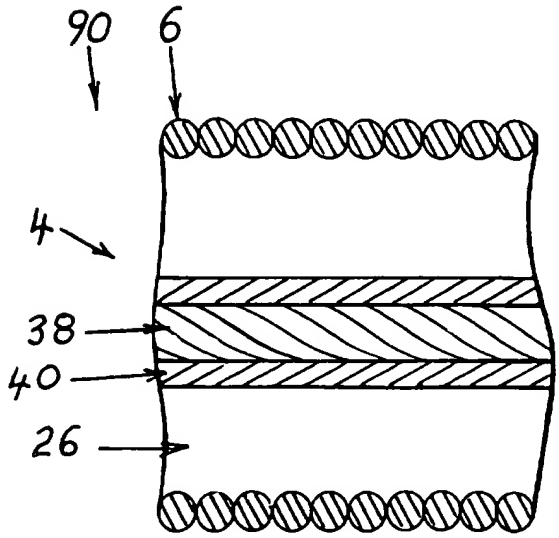
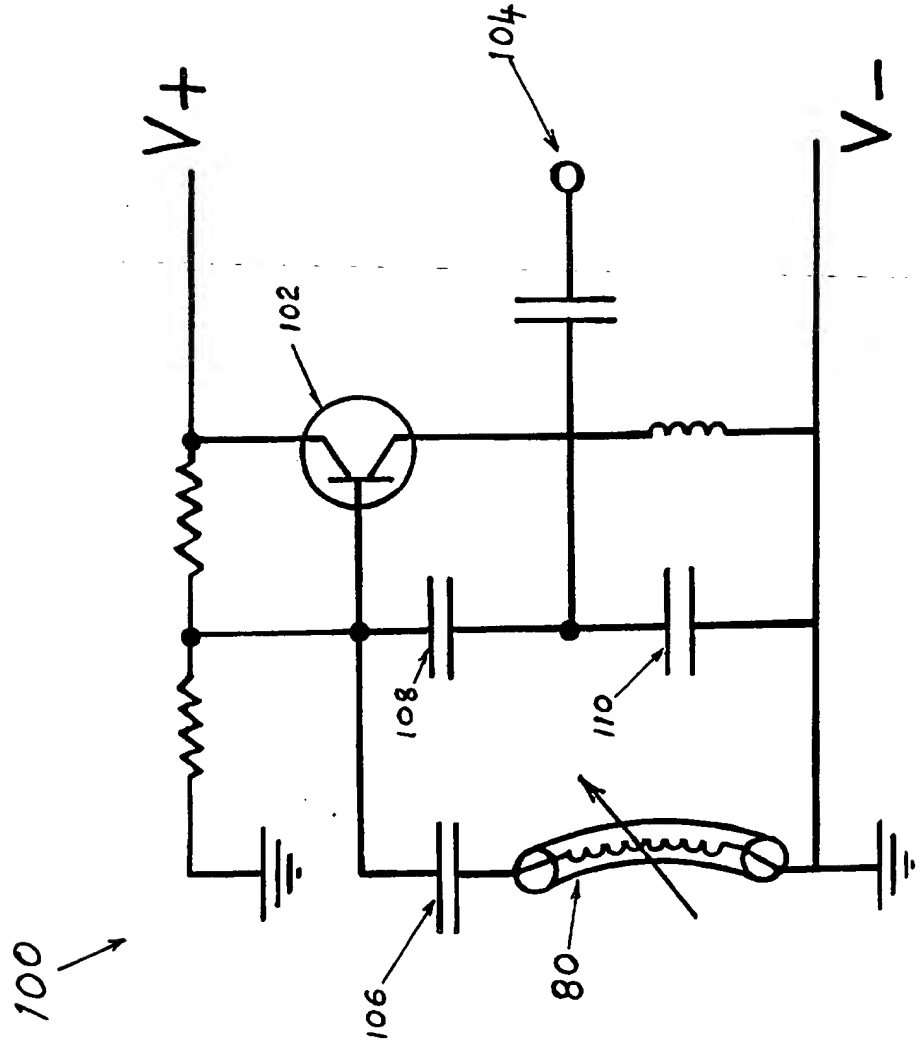


FIG 15

FIG 16



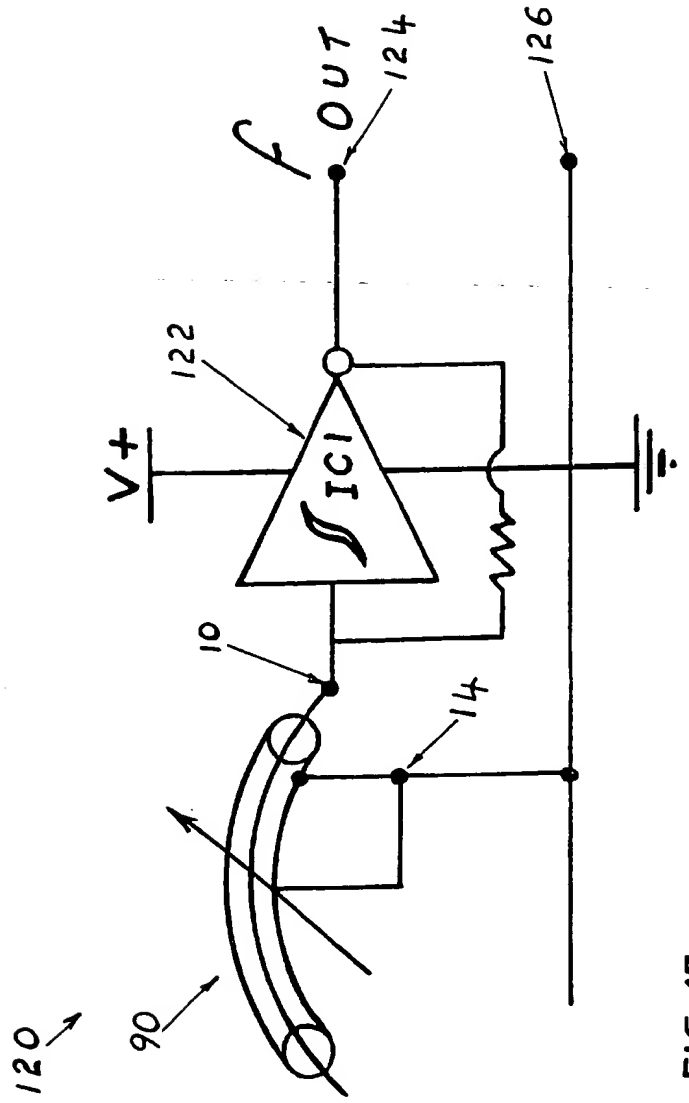


FIG 17

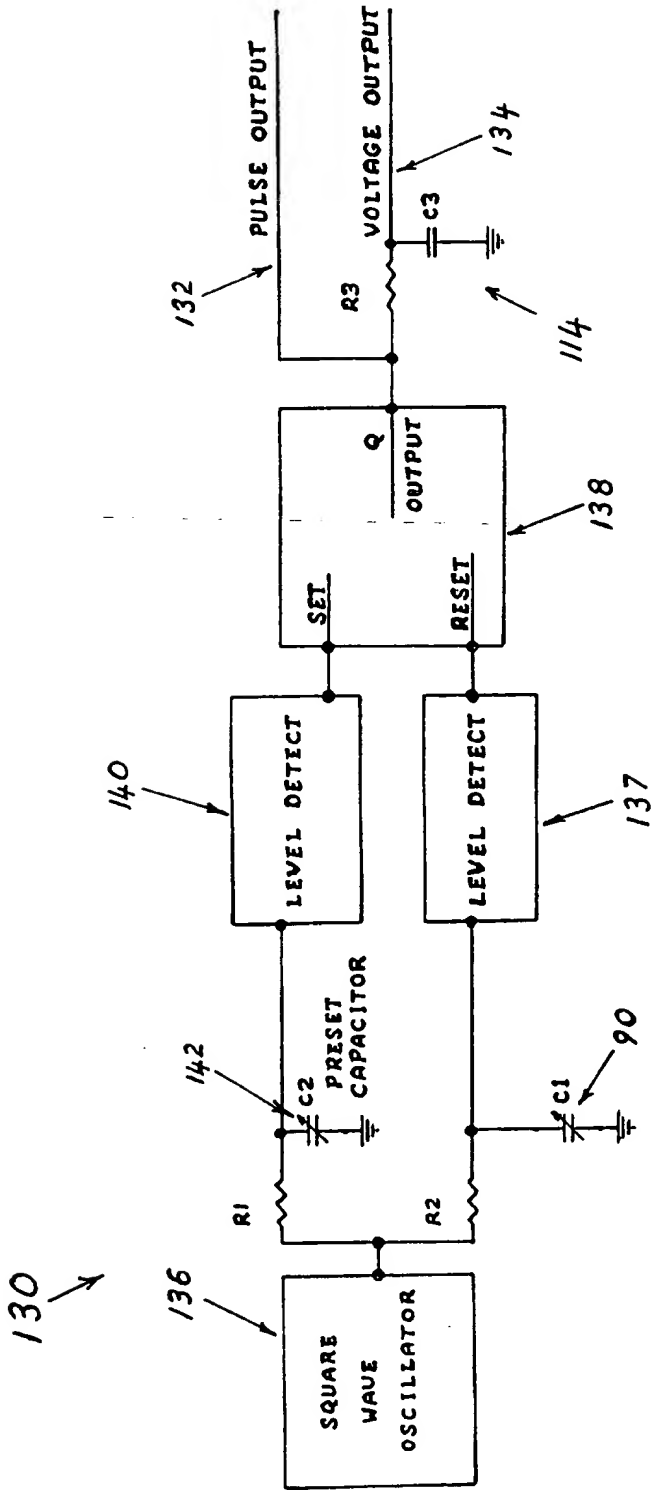

PULSE OUTPUT
VOLTAGE OUTPUT
134
C3
132
R3
114
Q
OUTPUT
138
SET
RESET
LEVEL DETECT
140
LEVEL DETECT
137
PRESET CAPACITOR
142
C2
C1
90
R1
R2
130
136
SQUARE WAVE OSCILLATOR

FIG 18

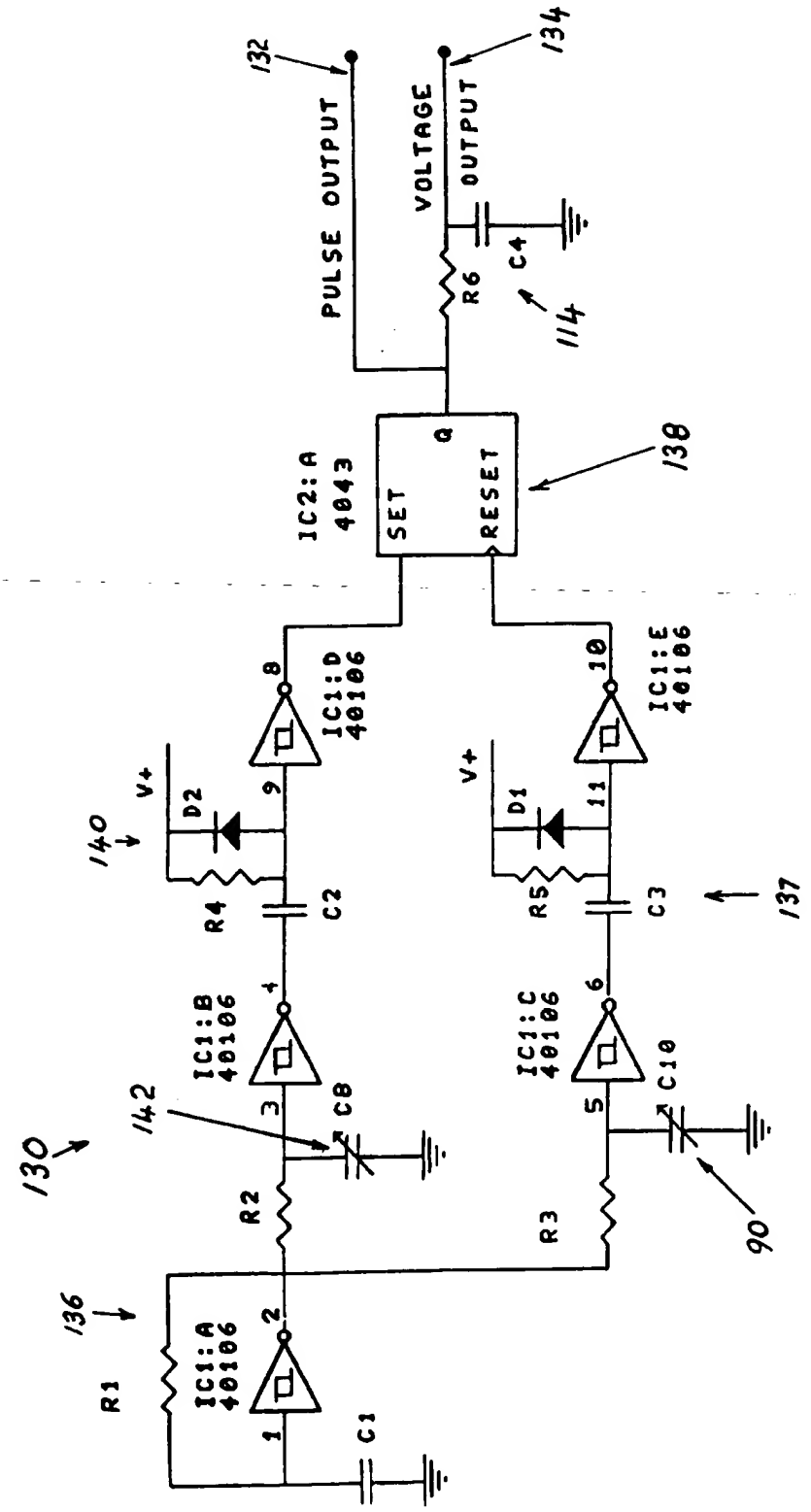
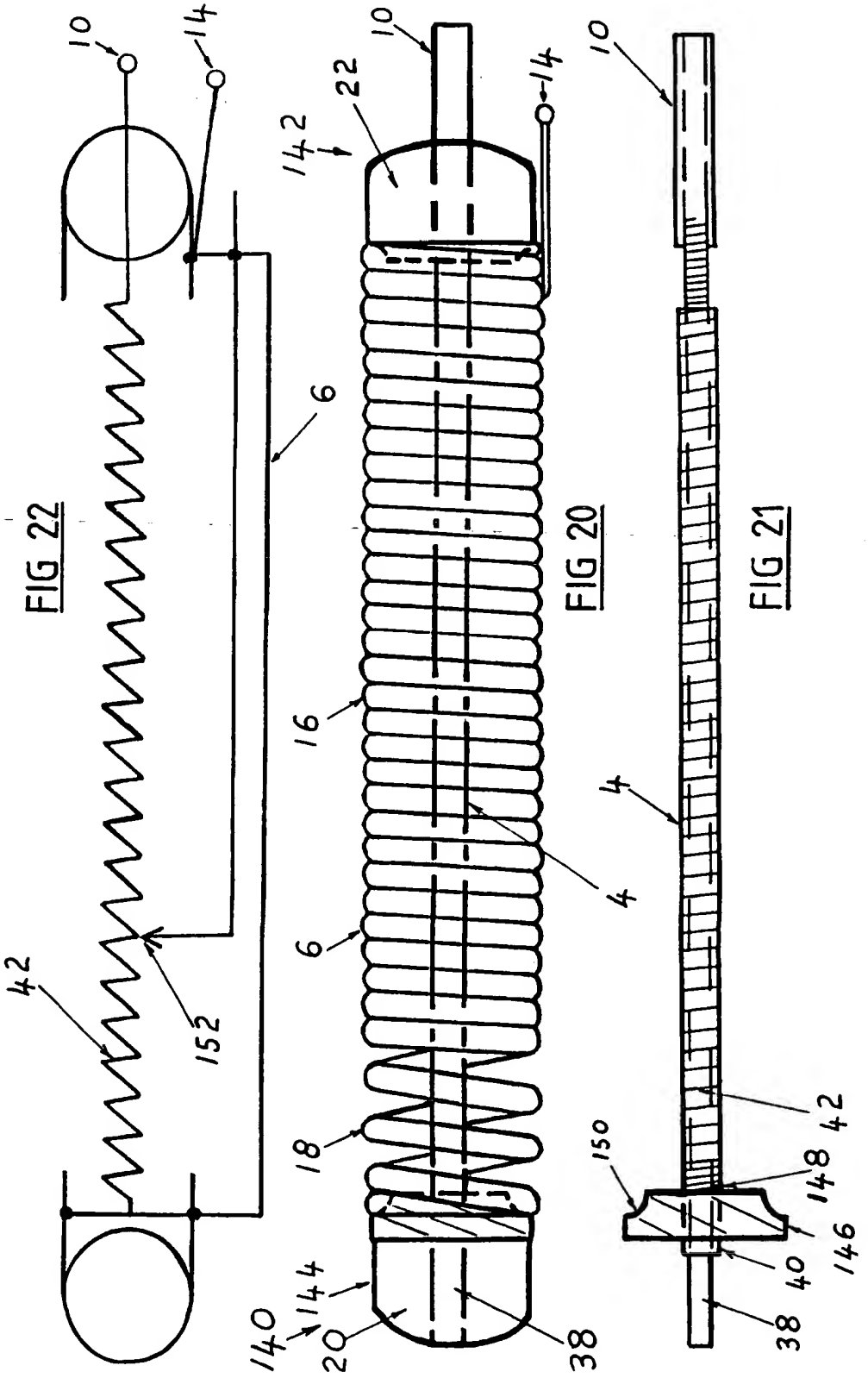

132
PULSE OUTPUT
134
VOLTAGE OUTPUT
C4
R6
114
IC2:A
4043
SET
Q
RESET
130
IC1:D
40106
IC1:E
40106
V+
D2
D1
140
R4
C2
R5
C3
137
IC1:B
40106
IC1:C
40106
142
C8
C10
130
R2
R3
90
136
IC1:A
40106
R1
C1

FIG 19


10
14
6
42
152
FIG 22
10
22
142
14
16
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18
144
140
20
38
FIG 20
10
4
42
150
148
146
40
38
FIG 21

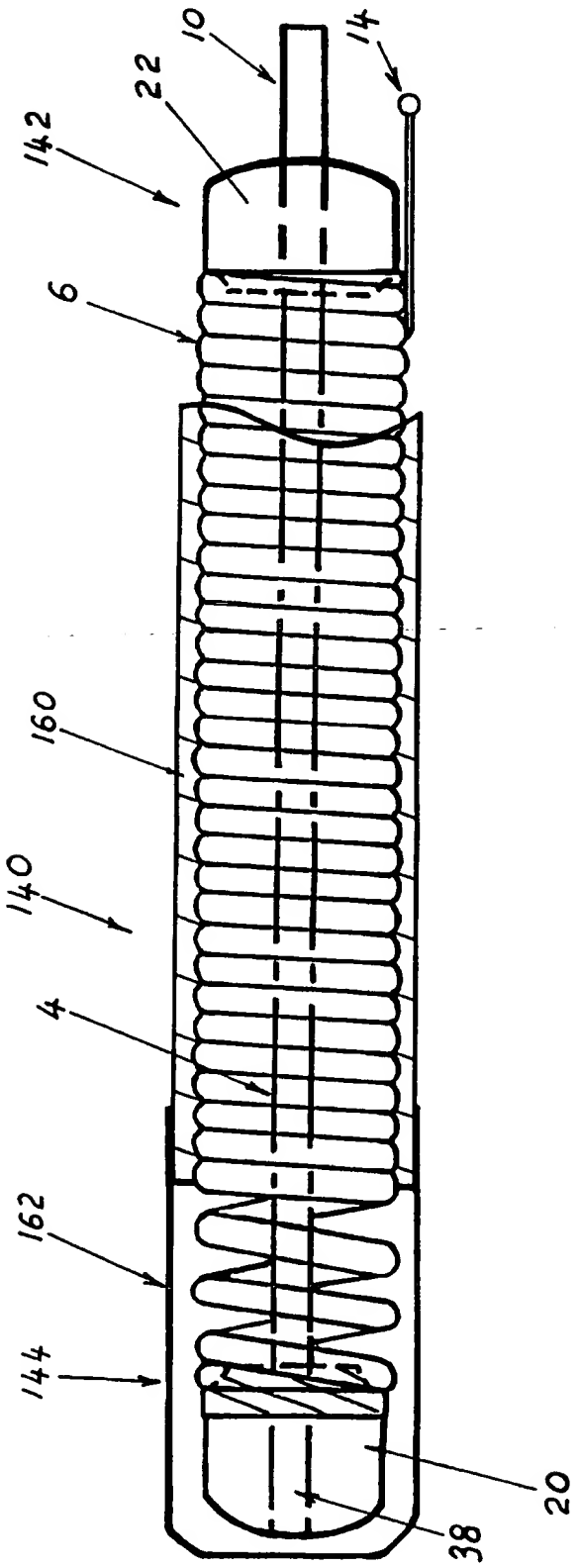

FIG 23

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/PCT/AU96/00118

A. CLASSIFICATION OF SUBJECT MATTER

Int Cl[6]: H01H 25/04, H01C 10/24, 17/04, H01f 21/06, H01G 5/18, G01P 13/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC: H01H 1/-, 3/-, 19/-, 21/-, 25/04, H01C 10/24, 13/-, 17/04, H01F 5/-, 21/-, 41/-, H01G 5/18, G01P 13/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU: IPC as above, Australian Class 04-22

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WPAT, JAPIO, USPM

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	AU, 85584/91 (652385) B (HAW) 9 April 1992	
X Y	See whole document	1,2,6,11-17,19,20 3,7,8,10
	Derwent Abstract Accession No. 91-256384/35, Class V02, JP, 03-166706 A (SHIMADA) 18 July 1991	
X Y	See abstract	1,2,6,11-17,19,20 3,7,8,10
	US 4715235 A (FUKUI) 29 December 1987	
Y	See abstract, Column 21, Figures 31 and 44(b)	7,8

[X] Further documents are listed in the continuation of Box C

[X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 June 1996	25TH JUNE 1996.

Name and mailing address of the ISA/AU
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Telephone No.: (06) 283 2164

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/PCT/AU96/00118

C (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Patent Abstract of Japan, P-698, page 34 JP, 62-266425 A (NETSUSHIN) 19 November 1987	
X	See Abstract	9
Y		3, 10
	DD 261457 A (VEB PLASTELEKTRONIK und SPEZIALWIDERSTANDE) 26 October 1988	
X	See Abstract	9
Y		3,10
	EP 280787 A (LEDA) 7 September 1988	
A	See Abstract and fig	1
	WO 95 22828 A (INTERLINK ELECTRONICS) 24 August 1995	
P,A	See Abstract and fig	1

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/PCT/AU96/00118

Box I **Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)**

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box II **Observations where unity of invention is lacking (Continuation of item 2 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

The claims are generally directed to a flexible conductor maintained in tension within another flexible conductor. Claim 9 refers purely to a method of winding a coil on a former.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims

2. ☒ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International Application No.
PCT/PCT/AU96/00118

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
US	4715235	CA	1277510	EP	206450	JP	61201045
EP	280787	BR	8800338	IT	1206891	JP	63253603
		US	4837548				

END OF ANNEX